Developing interventions for scaling up UK Upcycling

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Developing Interventions for Scaling Up UK Upcycling

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Abstract: Upcycling presents one of many opportunities for reducing consumption of materials and energy. Despite recent growth evidenced by increasing numbers of practitioners and businesses based on upcycling, it remains a niche activity and requires scaling up to realise its potential benefits. This paper investigates UK household upcycling in order to develop interventions for scaling up upcycling in the UK. Mixed methods were used in four stages: (a) Interviews to gain insights into UK upcycling; (b) a survey to discover key factors influencing UK upcycling; (c) intervention development based on the synthesis of interviews and survey; and (d) use of a semi-Delphi technique to evaluate and develop initial interventions. The results showed approaches to upcycling (e.g., wood, metal and fabric as frequently used materials, online platforms as frequently used source of materials), context for upcycling (e.g., predominant use of home for upcycling), factors influencing UK upcycling with key determinants (i.e., intention, attitude and subjective norm), important demographic characteristics considering a target audience for interventions (i.e., 30+ females) and prioritised interventions for scaling up (e.g., TV and inspirational media and community workshops as short-term high priority interventions). The paper further discusses implications of the study in terms of development of theory and practice of upcycling.

Keywords: carbon emissions; design; energy demand; intervention; policy; scaling up; sustainable consumption; sustainable behaviour; transition; upcycling

1. Introduction

Global greenhouse gas (GHG) emissions have continued to rise as a result of high levels of consumption [1,2]. Consumption-based emissions taking imported goods and services into consideration are about twice the level of production-based emissions in developed countries [1,3]. (GHG emissions are allocated to countries currently with three methods in common use: Territorial-based, production-based and consumption-based. The territorial-based method accounts for emissions within national territories and offshore areas over which the country has jurisdiction [4]. In the production-based method, unlike the territorial-based one, emissions from international aviation and shipping are allocated to the country of the vessels' operator, and emissions from international tourism are allocated based on the residence of the tourists rather than their destination [1]. The consumption-based method regards consumption as production minus exports plus imports [1].) UK production-based emissions between 1990 and 2009 revealed a 27 percent reduction, while consumption-based ones showed 20 percent growth between 1990 and 2008 [1,5,6]. Addressing energy demand for end use (i.e., energy consumption for residential, commercial, industrial and transportation purposes) [7] is therefore important to contribute to reductions in GHG emissions, along with improved

energy efficiency [8]. In particular, the UK has legal responsibility for reducing its GHG emissions by at least 80 percent from its 1990 levels by 2050 [9].

To this end, in 2013 the Research Councils UK set up six End Use Energy Demand centres to develop ways to save energy and reduce consumption [10]. The research described in this paper was undertaken in one of these centres, CIE-MAP (Centre for Industrial Energy, Materials and Products), which focused on identifying opportunities along the product supply chain to reduce materials and energy consumption in the UK [11]. The study explored upcycling as one of such opportunities and sought to develop interventions for 'scaling up' [12] upcycling with the ultimate goal of reducing carbon emissions [13]. The study focused on household upcycling. This paper utilises data described in greater detail in our previous paper on the study [14] and the lead author's Ph.D. thesis [15].

1.1. Upcycling

Upcycling is a neologism that has been defined as the process of retaining the high quality and value of materials and products in an open-loop (Materials recovered by parties other than the original producers [16]) industrial cycle [17–20]. It is the process of utilising used or waste materials, components and products to create a product of higher quality or value than the compositional elements [15,21]. Upcycling is often understood as a collective term incorporating 'creative' forms of reuse, repurpose, repair, refurbishment, upgrade, remanufacturing and recycling [14,22]. (Recycling is often in fact down-cycling, as the current dominant process downgrades the quality and value of the materials by mixing different materials and/or adding other materials or chemicals (e.g., mixed-up melt of aluminium) [23]. On the other hand, upcycling includes creative, alternative recycling processes to keep or increase the quality or value of the materials.) Without using the term upcycling, similar practices have been reported such as creative repair and repurposing at home [24], creative reuse of e-waste by everyday people [25], closed-loop supply chain with product recovery [26] or value-added recycling [27,28].

The concept and practices of upcycling are embedded in the circular economy, an alternative economic system which is restorative and regenerative in a closed loop material flow opposed to the current linear economic system based on extraction of new materials, production, consumption and disposal [29–31]. In principle upcycling extends the lifetimes of materials and products [15,32], and in so doing increases material efficiency and reduces energy consumption [15,33]. (Product lifetime extension is desirable for most products in order to decrease the environmental impact of products, whereas product lifetime optimisation is more appropriate in some cases, such as for more energy-efficient or eco-efficient products (e.g., energy-efficient washing machine, electric cars) [34–36].) It reduces solid waste [15,37,38]. In industries, upcycling-based businesses can be financially sustainable [39–41] and create new employment opportunities especially for disadvantaged people [42,43]. (Upcycling skills and techniques vary. Some upcycling processes involve high technology (e.g., improved recycling or remanufacturing) and highly skilled workers (e.g., bespoke upholstered chairs or high quality redesigned and remade clothing). Some upcycling can be done with minimal skills (e.g., simple refurbishment of furniture).) In households, individuals could gain sociocultural and psychological benefits (e.g., a sense of community, learning, being empowered and relaxation) and save money (by upcycling existing products rather than purchasing new ones) [21].

Craft-based upcycling in particular (e.g., creative repair, reuse, repurpose) has long been a part of human life. Until mass production, many products were used to the limits of their material utility or scavenged often due to scarcity [44]. (However, Rathje and Murphy's [45] careful examination of pre-industrial discards and practices showed that the demands of fashion and technical incompetence were the major factors that did not lead to material-use efficiency in many cases.) Mass production reduced costs and thereby introduced new (commercially defined) virtues of replaceability and throw-away mentality for economic growth (but vices from the sustainability point of view) [46]. (In particular, fashion and its shifts have been a huge driver for throw-away consumption. However, the cost reductions with mass production in fashion and other industries made formerly expensive

goods widely available, which is a positive social change for equity.) New consumerism replaced the pre-modern long-term engagement with a product with frequent replacement purchases and subsequent reduction in product quality, sometimes allegedly through planned obsolescence [47]. With the arrival of the consumer society, many useful skills for, for instance, maintenance and repair have largely been lost [48], due largely to relatively higher repair cost compared to replacement purchase [49]. The past few years, however, have seen a revival of upcycling, driven by multiple factors, such as growing concern for the environment, resource scarcity, increasing volumes of waste [50], the contemporary 'maker movement' [51], physical resources (e.g., Hackspaces and Makerspaces) [52] and digital resources (e.g., Instructables and iFixit). Despite the recent growth evidenced by increasing number of practitioners and businesses based on upcycling, it remains a niche or marginal activity [15] and requires scaling up to have a significant impact on the environment and society.

With increased interest in upcycling, the past decade has seen a surge of publications on upcycling, in disciplines ranging from design, engineering or management to consumer studies, and the body of literature is growing [53]. In general, upcycling has been understood chiefly as a sustainable approach or practice in engineering and technology [38,54–56], design [40,57–62] or business [40,63–65]. Upcycling research to date has focused on fashion and textiles [57,58,66–69], plastic [38,54,55,70] or wood [71–73]. For instance, Fletcher [57] depicted fashion and textile upcycling processes. Han et al. [59] illustrated innovative ways of utilising discarded textiles to recreate style and value. Busch [66] promoted fashion upcycling as a form of social activism. Park and Kim [58] delivered design guidelines for fashion upcycling. La Mantia [70] provided a review of different strategies for upgrading recycled plastics. Pol [54] described an innovative way of converting various waste plastics into a carbon microsphere, a value-added product. Wang et al. and Hossain et al. [71,72] showed how contaminated wood waste can be turned into rapid-shaping cement-bonded particleboards with a promising technology. Pennacchia et al. [73] presented the case where wood pallets could be used for new building envelop structures.

Previous research has not yet paid adequate attention to public interest in upcycling, such as upcycling-based craft and home DIY (do it yourself). (The examples of upcycling-based craft and home DIY include: (a) Refurbished and redecorated furniture; (b) redesigned and remade clothing; (c) fashion items (e.g., scarf, bag) or small home interior products (e.g., cushion) made from waste clothes or textiles; (d) old footwear decorated to revive its appearance; (e) jewellery made from used pieces of metal, plastic and fabric; (f) clocks made from used appliances, books, records, wheels and various other objects; (g) bowls made from vinyl records; (h) cups and plates made from glass bottles; (i) ukuleles made from cigar boxes; (j) redecorated snowboards or surfing boards; (k) upgraded bicycles with higher quality parts; and (l) garden furniture and planters made from reclaimed wood. The list goes on [22].) Few studies have been carried out to comprehend upcycling at the household level as an individual behaviour, which has been recognised as an avenue for further investigation and theory development [15,53,74].

1.2. Scaling Up

Scaling up is one of the central concepts used in transition theory [12,75,76]. Transitions are specific types of social change involving changes in perceptions, behaviours, technologies, environments, rules and regulations, characterised by a non-linear, long-term, structural transformation, through which the dominant way of fulfilling a societal need changes fundamentally [12]. One of the sub-fields in transition theory, transition dynamics, widely uses the framework of multi-level perspective [77,78]. The multi-level perspective explains the dynamics of transitions with three levels in a societal system—niche, regime and landscape—as an analytical tool [12,78,79]. Niches are new or alternative (often sustainable) practices and their related culture and structure such as upcycling. Regimes are mainstream activities or practices to fulfil the societal need, such as mass production based on virgin materials. The landscape is the environment of the societal system encompassing large-scale and long-term development, such as demographics and international politics [12]. Some academics add

niche-regime to niche and regime [75,80]. Niche-regimes are empowered niches that provide a viable or even competitive functioning compared to regimes and thus have considerable power (Figure 1).

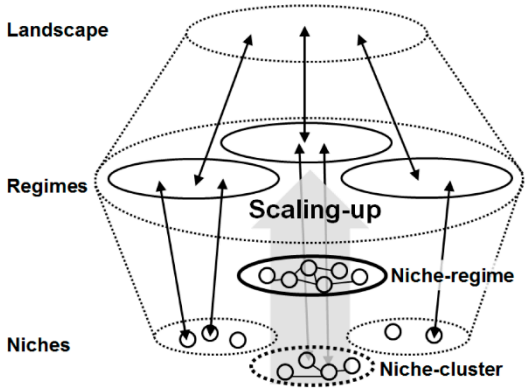

Figure 1. Scaling up from niches to regimes reproduced with permission from Van den Bosch, Transition Experiments: Exploring societal changes towards sustainability; published by Erasmus University Rotterdam, 2010.

Scaling up is the dynamic process of transitioning from niche to mainstream in niche-regime or regime in the multi-level perspective [75,76]. Through scaling up, a new constellation of (sustainable) practices and their associated culture and structure gains more influence and stability, therefore increasing its share in meeting a societal need. The consequences of scaling up are fundamental changes in the prevailing way through which societal needs are met (i.e., transition). Scaling up is not limited to change in the size of operations (e.g., small businesses becoming big businesses). It also concerns quantity, frequency, efficiency, effectiveness and quality related to practices. For instance, niches could increase their overall size by replicating themselves in different geographical areas.

This study is based on the understanding that the terms 'practice' and 'behaviour' can be used interchangeably [81]. In this respect, scaling up implies that sustainable behaviour that is initially unusual becomes common, or even dominant, behaviour. Upcycling, as a niche sustainable behaviour, might therefore be scaled up to become common in households and industries. The results of scaling up upcycling may include: (a) Ordinary consumers upcycling used or waste materials, components and products on a regular basis; (b) passionate upcycling hobbyists becoming producers of upcycled goods for consumers; (c) upcycling-based micro-enterprises becoming SMEs (small- and medium-sized enterprises), and even big businesses; (d) upcycling SMEs spreading and becoming accessible to consumers; and (e) manufacturers adopting upcycling production techniques and ideas for large-scale production.

2. Research Methodology

With the aim of developing interventions for scaling up UK upcycling, focusing on households, there were three objectives in this study. The first was to gain insights into UK upcycling. The second was to discover key factors influencing UK upcycling. The third was to formulate interventions for scaling up upcycling in the UK. The study used mixed methods [82] utilising interviews, a survey and a modified form of Delphi [83]. Figure 2 shows an overview of the research design and different methods employed in this study with four distinct stages.

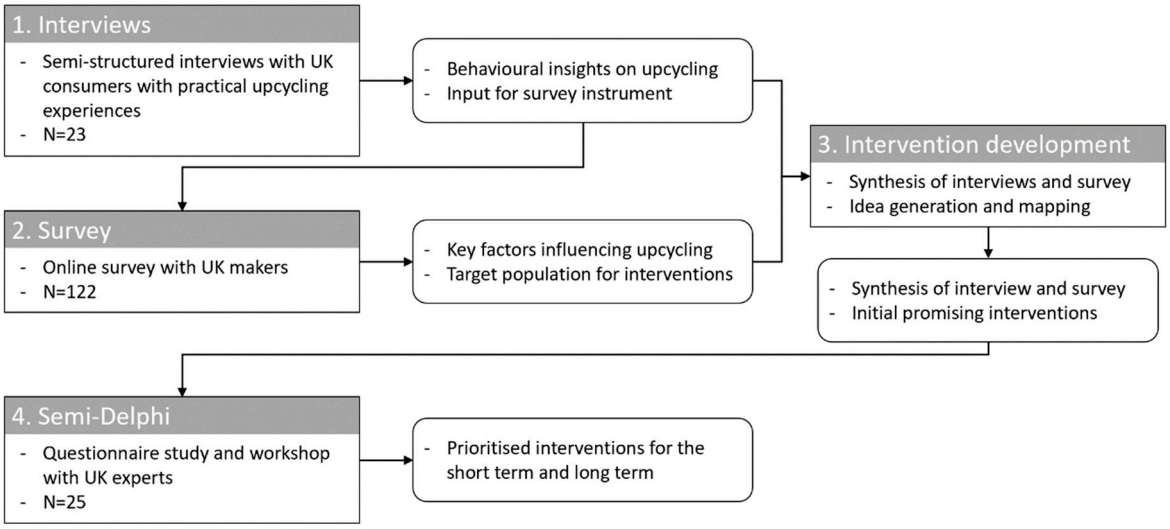

Figure 2. Stages in the methodology employed in this study.

2.1. Interviews

In order to gain meaningful insights into UK upcycling, a semi-structured interview [84] with twenty-three UK citizens who have practical experience of upcycling was conducted. The data collection was performed between 2014 and 2016. Interviews typically lasted between 30 and 90 min. Four interviews were conducted and analysed as a pilot study to ensure the validity and reliability of the study. All interviews were fully audio-recorded after obtainment of consent from all the study participants.

2.1.1. Instrument

The questions focussed on the interviewees' approaches to upcycling, the context for their upcycling and the factors that influenced their upcycling. The theoretical framework to explore factors influencing upcycling was Triandis's theory of interpersonal behaviour [85]. Most questions regarding the factors influencing upcycling were based on this theory, which has advantages and disadvantages [14]. A minor change was made as follows. Triandis defined the habit as the quantifiable amount of past behaviour, whereas the interview question explored a variety of upcycling-related activities both in present and past. See Figure 3 for the model and Appendix A for all questions.

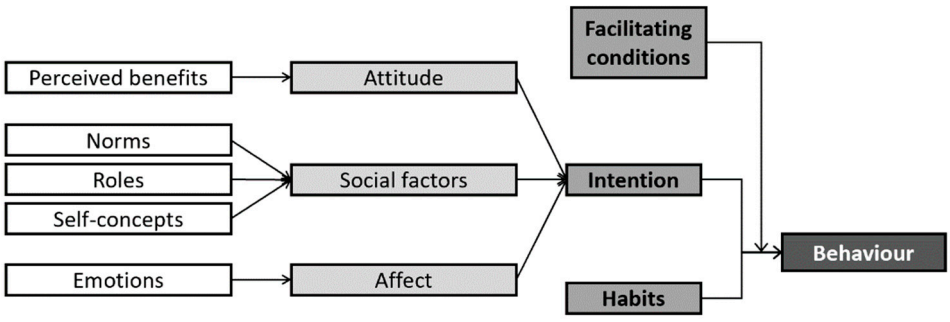

Figure 3. Triandis's theory of interpersonal behaviour modified for interviews.

2.1.2. Sampling and Participants

Hackspaces (and Makerspaces) were considered a suitable contact point for recruiting UK citizens with practical upcycling experience. (However, this selection of contact point could potentially exclude the citizens who engage in upcycling without utilising Hackspaces or Makerspaces; the snowball sampling identified those who do not necessarily use Hackspaces/Makerspaces for their upcycling

or other creative activities.) Hackspaces/Makerspaces provide local people with access to materials, tools and expertise. They have increased in number since 2009 and are in more than ninety locations in the UK now [86,87]. Ten Hackspaces in cities within nine regions of England were selected on the basis of the accessibility and level of active engagement of the members. Google fora of the ten Hackspaces/Makerspaces were used for posting a recruitment advertisement. The only inclusion criterion used was previous experience of upcycling. Thirteen participants responded directly to the advertisement and ten were identified by snowball sampling [88]. (The initial thirteen participants who responded directly to the advertisement were asked to introduce their family, friends, colleagues and/or acquaintances who engage in upcycling.) A total of twenty-three UK citizens with practical upcycling experiences participated in the interview. They were residents of nine cities and aged between 24 and 66 years old. Fifteen (65%) were male and eight (35%) were female.

2.1.3. Analysis

All interviews were transcribed and anonymised for thematic analysis [89] using QSR NVivo 10 Software. Each transcript entered into NVivo was examined line by line, and grounded codes were identified. Initial codes were constantly revised to fine-tune the coherent, collective themes.

2.2. Survey

In order to identify key factors influencing UK upcycling, a survey with 122 UK makers [51] was conducted (see Section 2.2.2 for definition of makers). The data was collected in 2015 using Google Forms (free internet survey platform). Several pre-tests and a pilot survey were used to ensure validity and reliability. A number of websites were used for administering the survey (see Section 2.2.2). The online survey first presented the definition of upcycling, then asked questions based on a combination model (see Section 2.2.1) and, finally, sociodemographic information was collected.

2.2.1. Instrument

Factors in a combination model (Figure 4) between Triandis's theory of interpersonal behaviour (TIB) [85] and Ajzen's theory of planned behaviour (TPB) [90] were used for survey questions, described in our previous paper [14]. The combination model has attitude, three social factors (subjective norm, personal norm and role beliefs) and perceived behaviour control as determinants of intention, and intention and perceived facilitating conditions as determinants of behaviour.

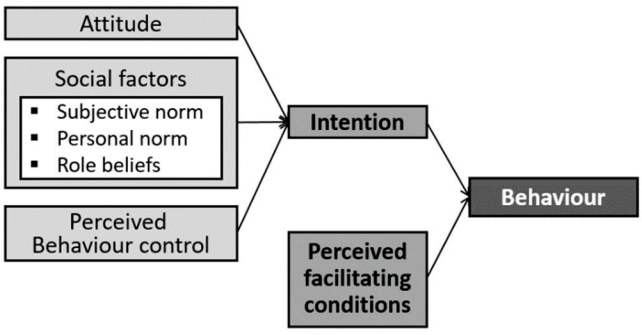

Figure 4. Combination model between Traindis's theory of interpersonal behaviour (TIB) and Azjen's theory of planned behaviour (TPB).

The majority of questions were created by adopting existing constructs that have been validated by other researchers [91–95]. The items in personal norm, role beliefs and perceived facilitating conditions, and the answer options for the frequency of upcycling were created on the basis of the interview results (i.e., context for upcycling and factors influencing upcycling). Seven-point Likert scale (1: "strongly disagree"; 2: "disagree"; 3: "somewhat disagree"; 4: "neither agree nor disagree"; 5: "somewhat agree"; 6: "agree"; and 7: "strongly agree") was used to measure subjective norm, personal norm,

perceived behaviour control and intention. A 'not applicable' option was additionally provided for role beliefs. A different seven-point Likert scale (1: "not at all"; 2: "to a very small extent"; 3: "to a small extent"; 4: "to a moderate extent"; 5: "to a fairly great extent"; 6: "to a great extent"; and 7: "to a very great extent") was used to measure perceived facilitating conditions. Seven-point bipolar adjective scales (e.g., 1: "unpleasant"–7: "pleasant") were used to measure attitude. Eight options were provided for the frequency of behavior. See our previous paper [14] for survey questions and answer options.

2.2.2. Sampling and Respondents

Target audience of the survey was UK 'makers' as defined by Anderson [51]: Makers are those who are interested in creative activities such as craft, painting, knitting, sewing, beading, scrap-booking, cooking, gardening or other forms of making something. They are potentially anyone. The presumption in this target population was that these UK makers have potential to utilise upcycling for their creative processes. While they are not nationally representative, they may be the most relevant to the topic of investigation. For practical limitations (e.g., difficulty of identifying the sampling frame [96], limited time and resources), purposive sampling [96,97] was used. Reflecting on the fact that some makers are active in using digital resources such as Instructables or iFixit to produce or consume digital contents [98,99], during the previous study interviewees were asked about the websites they visit on a regular basis for upcycling. All nominated websites were used for contacting the target population. The implication of this sampling approach (i.e., targeting those who are actively engaged in the digital space) is that the sample did not include those makers who philosophically reject the digital space as part of their making identity.

In total, 122 responses were used for analysis. The majority (70%) had completed higher education. About one half were aged between 30 and 49 years. See our previous paper [14] for detailed demographic information.

2.2.3. Analysis

The responses were analysed by employing logistic regression and non-parametric statistics for comparing groups (Mann-Whitney U Test for gender difference and Kruskal-Wallis H Test for group differences based on age, education, employment and occupation.), using SPSS (Statistical Package for the Social Science) version 22.0. For logistic regression analysis, ordinal and nominal data with more than two choices were converted into binary nominal data. A limited number of items were extracted for the logistic regression based on a rule of thumb (minimum ten cases for each predictor) [14].

2.3. Intervention Development

The results from the interview and survey studies were synthesised in order to formulate interventions for scaling up upcycling. Synthesis is central to all design, and an integral part of the generation of opportunities; it is critical in sense-making, organisation and in identifying important connections between seemingly unrelated matters, often leading to new, innovative and convincing ideas [100,101]. This creative synthesis included attention to implications for scaling up in the generation of new ideas for scaling up upcycling. Preliminary ideas were mapped onto behaviour intervention models developed by Defra (Department for Environment, Food and Rural Affairs) [102,103] and Michie et al. [104]. Defra's 4Es model is a well-known mapping tool comprising four broad categories of enable, encourage, engage and exemplify; interventions to influence behaviour are most effective when approaches are combined from across the four categories [105,106]. Michie et al.'s model presents a comprehensive list from a systematic review of nineteen frameworks for behaviour change interventions. From the mapping table, fifteen interventions were formulated for subsequent testing. See Section 3.3 for full details.

2.4. Semi-Delphi

A modified form of the Delphi technique [83] (described here as semi-Delphi) was used in order to evaluate and further develop intervention ideas. Delphi is a method used for decision making by obtaining insights of experts and using their informed judgements in a systematic way [83]. The semi-Delphi consisted of a questionnaire study to explore and evaluate intervention ideas and a subsequent workshop to further discuss the ideas and draw conclusions (cf. a series of questionnaires used in a traditional Delphi). The data was collected between 2015 and 2016 from twenty-five relevant UK experts. The questionnaire was administered via email or in person. The workshop took place in January 2016.

2.4.1. Instrument

Instructions for the questionnaire, presentation style and rating scales were designed on the basis of the proposals by Adler and Ziglio [107]. Fifteen interventions for scaling up upcycling (Appendix B) and four instructions to respondents (Table 1) were provided.

Table 1. Semi-Delphi questionnaire instructions.

No.	Instruction
01	Review all interventions.
02	Make comments on any intervention.
03	Rate the level of importance and feasibility of each intervention - Importance: Potential impact on scaling up (1: Very unimportant–5: Very important) - Feasibility: Technical, economic and political feasibility (1: Definitely unfeasible–5: Definitely feasible)
04	Vote for the most suitable actor(s) for each intervention (amongst government, local authorities, companies, NGOs (non-governmental organisations), designers, others—specify)

2.4.2. Sampling and Participants

A keyword-based search was conducted to identify names of experts in relevant disciplines in the UK. (Keywords such as "behaviour change", "environmental policies" and "sustainable design" were used to identify literature (mostly journal articles published in high impact journals) and main authors (based on number of publications and citations, and whether the person is a lead author) using a range of digital bibliographic databases such as Google Scholar, Elsevier, Springer and Scopus. The authors' geographical area was limited to the UK.) Fifty-two UK experts were selected on the basis of their expertise in behaviour change, environmental policies, social innovation, sustainable design, sustainable development and sustainable transition. Invitation emails were sent to these pre-selected experts, and twelve responded. A further thirteen experts were identified from the four universities in CIE-MAP (see Section 1).

A total of twenty-five experts responded to the questionnaire. The respondents were fifteen males (60%) and ten females (40%) from the areas of policy, engineering, psychology, sociology, art and design, business management and economics. Their affiliations included Green Alliance, Greengage, and eight universities (Bath, Cardiff, Leeds, Manchester, Nottingham Trent, Sheffield, Surrey and Sussex). Among the respondents, eleven participated in the subsequent workshop (seven males and four females). These experts are limited to their academic disciplines and professional practices of policy making and public engagement.

2.4.3. Analysis

Simple statistical analysis (mean, standard deviation and frequency) was used for analysing quantitative data from the questionnaire. The expert discussions during the workshop were fully

audio-recorded (with the consent of all participants), transcribed and anonymised. The results were reported without interpretation.

3. Results

This section describes the results of each study, structured around each method: (a) Interviews (to gain insights into UK upcycling); (b) survey (to discover key factors influencing UK upcycling); (c) intervention development (to generate interventions for scaling up upcycling); and d) semi-Delphi (to prioritise interventions for short and long terms).

3.1. Interviews: Insights into UK Upcycling

The interview results are summarised here in three categories: (a) Approaches to upcycling; (b) context for upcycling; and (c) factors influencing upcycling based on more comprehensive reports [15,108].

3.1.1. Approaches to Upcycling

The most common upcycling materials turned out to be (used/waste) wood (and wooden furniture) (n = 8) followed by metal (5), electronics (4), fabrics (3) and packaging (3). (The potential sampling bias (potentially excluding those citizens who engage in upcycling without utilising Hackspaces or Makerspaces) may have caused the difference in materials used for upcycling.) Eight interviewees pointed out that they used anything that they had already or that was required for their particular upcycling 'project' (most interviewees referred to upcycling activities as projects). The typical route to acquire the materials for upcycling was through online shops or networks such as eBay, Gumtree, Freecycle or Freegle (n = 7). The second most typical way was from skips (6). The third was charity shops and other local shops (4). Six interviewees remarked that they obtained the materials from 'anywhere' including their own house or from other people. The criteria for selecting materials were project requirement (n = 8), potential value of the materials (5), financial saving (4), quality of the materials (4), personal preference (3) and perceived ease of use (2). The end product usage after upcycling was mostly for themselves at home (n = 15). Another common usage was as a gift to family, friends or acquaintances (8). The third most common group of usage was selling to others (through online market places or physical shops) (7) or showcasing in exhibitions or maker fairs (3). Seven interviewees without current commercial activities expressed their aspiration to sell their products.

3.1.2. Context for Upcycling

The interviewees were asked when they upcycled and their answers were predominantly any suitable time (e.g., "Whenever I have free time, mostly weekday evening", "If I feel like I have a block of time on weekends") (n = 11). Two interviewees stated that they upcycled at particular timings as a response to particular events. The frequency of upcycling was varied and dependent on the project. Four interviewees indicated that they upcycled almost every day. Other answers ranged from once a week to once a year.

The usual place for upcycling was the interviewee's home (n = 7), followed by a shed or garage (6). Six interviewees used a local Hackspace or Makerspace. Three utilised a studio or workshop (individual or shared). When the interviewees were engaged in upcycling, they were typically by themselves (n = 17) or collaborating with local experts (6). Three mentioned their partner as a collaborator or a companion. Other answers included family members (2), friends (2) and people in online communities (2).

3.1.3. Factors Influencing Upcycling

The primary perceived benefits (determinant of attitude in Figure 3) of upcycling were economic benefit (e.g., "It's nice to pick something up, so five pounds, and make it look like something which is

worth sixty-five pounds") (n = 14) and environmental benefit (e.g., "Clearly we use less resources") (13). Nine interviewees mentioned enjoyment and fun in the creative process and a feel-good factor. Seven interviewees pointed out the product personalisation (Product personalisation is a creative process that defines or changes a product's attributes (e.g., appearance or functionality) to increase its personal relevance to an individual [109,110].) as a benefit. The learning experience, as well as recognition and appreciation from others, were listed by five each. Miscellaneous answers included improving the home (n = 3), being creative (2), relaxing (2), feelings of empowerment (2), tidying things up (1), helping projects at schools and universities (1), feeling productive (1) and stopping negative thinking (1). Social norms (part of social factors in Figure 3) as a part of motivation for upcycling were mainly related to being environmentally conscious (n = 10). Relevant roles (social factor) for upcycling were occupational roles (n = 8) and relationship roles in family, for friendship or for community (6). Self-concepts (social factor) related to upcycling were mainly as environmentalists (3), makers (3) or problem solvers (2).

The dominant emotions (determinant of affect in Figure 3) experienced during the upcycling process were satisfaction (pleasure from hands-on processes and a sense of achievement) (n = 15) and frustration (related to non-standardised and defective materials) (14), often at the same time. Other emotions included happiness (8), pride and excitement (6 each). Activities relating to upcycling that the interviewees were habitually engaged in were art and craft (e.g., woodwork, painting, knitting, crochet, metalwork) (n = 9), hacking, tinkering and digital creation (8), and home DIY, simple repair and fixing (7). Childhood habits related to upcycling included drawing, making and building, influenced and inspired by family members (n = 12), school curricula (8) and TV programmes (3).

Barriers (part of facilitating conditions in Figure 3) to upcycling were (in the order of importance based on the number of interviewees' answers): A lack of space (n = 7), social situation and cultural perception (e.g., prevalent consumerism and negative perception of upcycling) (7), a lack of tools (6), safety issues (e.g., use of power tools) (5), a lack of spare time (5), a lack of interest (3) and quality issues (e.g., defective waste materials). Facilitators (facilitating conditions) for upcycling were (in the order of importance): Having enough space (n = 11), having all the right materials (6), Hackspace (6), inspiration from people and experience (6), tools (5), competence (i.e., knowledge and skills) (5), internet (information and supporting online communities) (4), social situation and cultural perception (e.g., maker culture) (4), companions (4), interest and imagination (3), teachers (2) and spare time (2).

3.2. Survey: Key Factors Influencing UK Upcycling

Following detailed analysis in our earlier paper [14], the survey results are summarised here in two categories: Key factors influencing upcycling and demographic characteristic.

3.2.1. Key Factors Influencing Upcycling

Three models based on Figure 4 that could potentially explain upcycling were tested using logistic regression. The first model (Figure 5a) had three intention items ("I intend to upcycle", "If I have the opportunity, I will upcycle" and "My likelihood of upcycling is high") and seven perceived facilitating conditions (A lack of materials, imagination, inspiration, tools, teachers/helpers, skills and information, chosen for the significant correlations with frequency of upcycling [14].) to explain behaviour (i.e., frequency of upcycling). The model showed statistically significant relationships with unique contribution (Logistic regression examines multiple independent variables to reveal the unique contribution of each variable after adjusting for the others (answering questions such as "How much more does a certain variable/factor contribute to a dependent variable compared with other variables?") [111].) by one intention item ("I intend to upcycle"), confirming that intention explains the frequency of upcycling (weak contribution by perceived facilitating conditions).

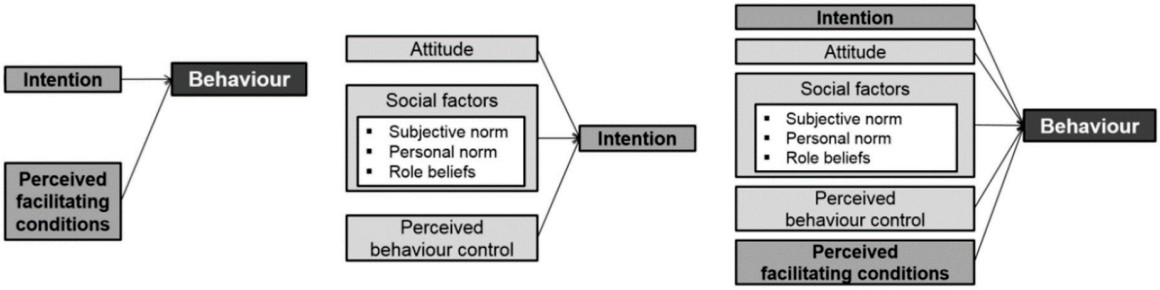

Figure 5. Three models tested using logistic regression: (**a**) First model to explain behaviour (frequency of upcycling); (**b**) second model to explain intention; (**c**) third model to explain behaviour based on all factors [14,15].

The second model (Figure 5b) included ten items (two items per factor chosen for the significant correlations with intention) [14] for attitude, social factors and perceived behaviour control to explain behaviour intention. The model uncovered statistically significant relationships with unique contribution by one attitude item ("To me, taking part in upcycling is pleasant"), confirming that attitude explains the intention to upcycle (moderate contribution by social factors and weak contribution by perceived behaviour control).

The third model (Figure 5c), having all factors as potential determinants to explain the frequency of upcycling, contained nine items from all factors (each factor with one item except for perceived facilitating conditions with three items chosen for the significant correlations with the frequency of upcycling) [14]. This model revealed statistically significant relationships and better explained the behaviour (frequency of upcycling) than the initial model (Figure 5a). (The initial model (Figure 5a) explained between 22.4% and 30.6% of the variance in frequency of upcycling, whereas the third model (Figure 5c) explained 34.0% and 46.4% of the variance in frequency of upcycling [14].) Intention item and subjective norm item made unique contributions to the model, confirming that intention (and therefore attitude) and subjective norm are key factors influencing upcycling.

Taking these three logistic regression analyses into account, Figure 6 proposes a new model to explain upcycling behaviour. Attitude strongly influences intention, while social factors have a moderate influence and perceived behaviour control a weak influence. In explaining the behaviour (frequency of upcycling), intention and subjective norm exert a strong influence, whereas all the other factors exert a weak influence.

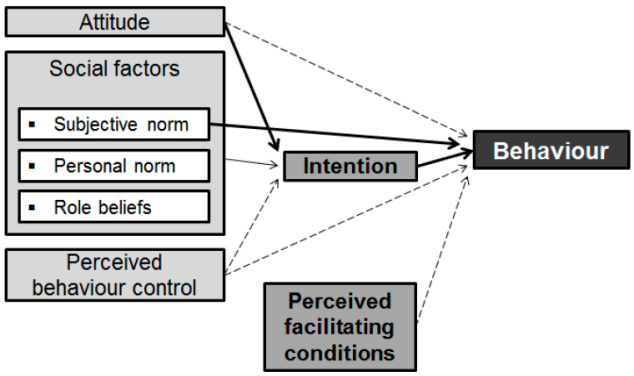

Figure 6. New proposed model to explain upcycling (→ strong influence; → moderate influence; - -> weak influence) [14,15].

3.2.2. Important Demographic Characteristics

Some important demographic characteristics were identified by analysing group differences based on age, occupation, employment status and educational level. Statistically significant differences were found between males and females with a general tendency towards higher median scores for female respondents (e.g., subjective norm (p = 0.039**, Md (Male) = 5, Md (Female) = 6), personal norm (p = 0.014**, Md (M) = 4, Md (F) = 5)). Three age groups (under 30 (Group 1), 30 to 49 (Group 2), 50 and over (Group 3)) showed statistically significant differences with higher median scores by respondents who were 30 years old or older than those under 30 (e.g., role beliefs (p = 0.036**, Md (Group 1) = 4, Md (Group 2) = 5, Md (Group 3) = 5), behaviour (p = 0.003**, Md (Group 1) = 4, Md (Group 2) = 5, Md (Group 3) = 5). Based on five occupation category groups (business and sales (Group 1); creative art and design (Group 2); science, engineering and technology (Group 3); teaching and education (Group 4); others (Group 5)), statistically significant differences were found. Overall the respondents in creative art and design scored higher median values, whereas those in science, engineering and technology scored lower median values (e.g., subjective norm (p = 0.037**, Md (Group 1) = 4, Md (Group 2) = 5, Md (Group 3) = 3.5, Md (Group 4) = 4, Md (Group 5) = 4). Regarding the three employment status groups (full-time employed (Group 1), part-time or self-employed (Group 2), not currently employed (Group 3)), group differences were identified with some higher median scores by part-time or self-employed respondents (e.g., role beliefs (p = 0.037**, Md (Group 1) = 4, Md (Group 2) = 5, Md (Group 3) = 4), perceived behaviour control (p = 0.049**, Md (Group 1) = 5, Md (Group 2) = 6.9, Md (Group 3) = 5)). No statistically significant difference was found in the dataset across educational level groups. Separate tables of all statistical test results on group differences can be found in our latest paper addressing the survey study in detail [14].

3.3. Intervention Development: Interventions for Scaling Up Upcycling

This section describes how interview and survey studies fed into formulating interventions using Defra's 4Es model [102,103] and Michie et al.'s policy categories [104]. The results are presented in two categories: Synthesis of interviews and survey, and interventions.

3.3.1. Synthesis of Interviews and Survey

The main findings from the interviews and survey were synthesised and implications for scaling up upcycling were drawn (Table 2).

3.3.2. Interventions

Two important implications regarding interventions for scaling up from the synthesis were approach to developing interventions for scaling up (shaping intention by building a positive attitude and establishing a positive subjective norm) and target audience for interventions (30+ females working in art and design) (Table 2). Other implications were used for intervention idea generation. Defra's 4Es model [102,103] and Michie et al.'s model [104] were used to create a mapping table ('Engage' was not included in the mapping table as it concerns general guidelines for implementation such as "working with trusted intermediaries" in order to get people involved.) and extra ideas were generated and added by the lead author (Table 3). From Table 3, fifteen interventions were formulated for testing/evaluation (Appendix B).

Table 2. Synthesis of the main findings and implications for scaling up upcycling.

Category	Main Findings	Implications for Scaling Up
Approaches to upcycling	Frequently used materials identified	Target wood, furniture, metal, electronics, fabric and packaging as mainly used materials provision
	Frequently used source of materials identified as online	Provide online service (for searching and purchasing) for improved materials provision
	Major material selection criteria identified	Provide estimated potential value, estimated money saving and quality rating for used materials
	End product use mainly for themselves at home with aspiration for commercialisation	Provide specialised services such as business feasibility assessment, technical safety test and market identification
Context for upcycling	Predominant use of home for upcycling	Provide tools hiring/rent service or lower membership price for Hackspace/Makerspace
	Interest in good companions or collaborators	Provide a community event on a regular basis to enable people to identify collaborators, companions or business partners.
Factors influencing upcycling	Particular benefits emphasised	Stress economic, environmental and emotional/psychological benefits when providing information about upcycling
Key factors	Key factors identified as intention, attitude and subjective norm	Design and prioritise interventions to shape intention, build positive attitude and establish positive subjective norm (culture)
Important demographic characteristics	Females, aged 30 years or older, working in art and design, and part-time or self-employment	Target 30+ females working in art and design for interventions

Table 3. Interventions for scaling up.

Action	Category	Elements	Intervention
Provide facilities (Enable)	Environmental restructuring/service provision/social planning	- Materials - Tools - Space	- Improve materials provision service/system (online system providing estimated potential value, money saving and quality rating of used materials) - Design tool hire service - Improve community workshops - Lower membership price of community workshops - Provide a reuse/upcycle centre
Ensure ability (Enable)	Education and training	- Curriculum - Training - Event - Competitions - Business service	- Advance curriculum in art and design - Design toolkits for novice upcyclers - Provide the best upcycling practices, skills and knowledge - Design and organise community events, training, competitions and business service (feasibility and safety)
Build understanding (Enable)	Persuasion/communication/ marketing	- Handbook/brochures - Social marketing - Promotion campaigns - Media demonstration	- Design and disseminate effective communication and demonstration materials in prints and online emphasising economic, environmental and emotional benefits - Design and execute effective promotion campaigns

Table 3. *Cont.*

Action	Category	Elements	Intervention
Incentives (Encourage)	Incentivisation/fiscal/ regulation/legislation	- Tax benefits - Subsidies - Awards - Grants	- Provide upcycling businesses with tax benefits, subsidies and awards - Provide upcycling initiatives and research institutions with subsidies, grants and awards
Lead by example (Exemplify)	Modelling	- High profile projects - Change in government procurement	- Commission upcycling projects by popular artists, designers or makers - Change procurement policy to favour upcycled goods

3.4. Semi-Delphi: Prioritised Interventions for Scaling Up Upcycling

The fifteen interventions were evaluated in terms of importance (i.e., potential impact on scaling up) and feasibility (i.e., whether or not the intervention could be implemented on the basis of technology/resource availability, economic viability and political acceptance) through the questionnaire study. The results showed that eight interventions scored relatively high mean values (at least 3.5 out of 5) for importance: Community workshops, upcycling centre, materials provision service, curriculum enrichment, TV and inspirational media, incentives for upcycling businesses, incentives for upcycling initiatives/research and government procurement change. Nine interventions scored relatively high mean values for feasibility: Community workshops, novice toolkits, curriculum enrichment, community events, competitions, business consulting, communication, campaign and TV and inspirational media (Table 4).

Table 4. Importance and feasibility of each intervention.

Intervention	Importance		Feasibility	
	Mean	SD	Mean	SD
Community workshops	3.52	0.71	3.60	0.87
Novice toolkits	3.25	1.15	3.67	1.09
Upcycling centre	3.72	1.10	3.48	0.96
Materials provision service	3.90	0.85	3.35	0.75
Curriculum enrichment	3.72	1.02	3.96	0.84
Community events	3.33	1.01	4.00	0.80
Competitions	2.84	1.21	4.12	0.88
Business consulting	3.26	0.96	3.65	0.88
Communication	3.16	1.25	4.04	0.86
Campaign	2.92	1.04	4.00	0.87
TV and inspirational media	3.60	0.87	4.12	0.78
Incentives for upcycling businesses	3.86	1.08	2.73	1.12
Incentives for upcycling initiatives/research	3.56	0.96	3.20	1.08
Commissioned projects	3.09	1.12	3.38	0.92
Government procurement change	3.64	1.11	2.84	1.31

When the respondents were asked about the most suitable actor(s) for each intervention, most voted for multiple actors. For example, companies and NGOs with the expertise of designers might be the most suitable actors for designing and providing toolkits for novice upcyclers. Local authorities partnering with NGOs might be most suitable for operating an upcycling centre aligned with the existing waste collection and management system (Table 5).

Table 5. Most suitable actor(s) for each intervention (with multiple choices).

Intervention	Number of Answers (n)						Others Specified
	Gov [1]	LA	Com	NGO	Des	Oth	
Community workshops	3	11	2	10	3	5	Communities, volunteers
Novice toolkits	1	2	10	8	8	1	Communities
Upcycling centre	4	20	3	8	0	2	WRAP [2]
Materials provision service	4	3	12	3	6	0	NA
Curriculum enrichment	13	5	1	0	6	9	Educational institutions
Community events	2	12	1	14	2	2	Communities
Competitions	6	7	7	8	4	12	Educational institutions, communities
Business consulting	2	7	8	9	3	2	Business consultants, researchers
Communication	9	6	9	11	6	3	Communities, WRAP
Campaign	2	3	10	9	7	1	Communication specialists
TV and inspirational media	1	0	5	11	10	6	Broadcasters
Incentives for upcycling businesses	20	1	1	0	0	0	NA
Incentives for upcycling initiatives/research	20	2	4	2	0	3	Research Councils, Arts Council
Commissioned projects	6	3	10	5	9	0	NA
Government procurement change	22	7	3	2	0	0	NA

[1] Gov (government), LA (local authorities), Com (companies), NGO (non-governmental organisations), Des (designers), Oth (others); [2] Waste and Resources Action Programme.

Taking into account the questionnaire results, the workshop participants used card sorting exercises to collectively categorise interventions as big, medium or small impact, and feasible in the short term (two years) or long term (ten years). These exercises resulted in two short-term high priority interventions, four short-term medium priority interventions, and three long-term priority interventions. The short-term high priority interventions were TV and inspirational media, and community workshops. The short-term medium priority interventions were upcycling centre, materials provision service, government procurement change, and community events. The long-term priority interventions were incentives for upcycling businesses, incentives for upcycling initiatives/research, and curriculum enrichment. Each intervention was further discussed in the workshop as follows.

3.4.1. Short-Term High Priority Interventions

Most workshop participants agreed that TV and inspirational media (including new digital media such as YouTube and Pinterest) could have significant, long-term impact on public perceptions and awareness. In order to set new norms and culture, rather than creating a passing fad, making the TV show or other media programmes last for several years was viewed as critical (e.g., British Bake Off). Some participants recommended involvement of high profile designers, ex-armed forces (e.g., for refurbishing their own houses) and/or celebrities. The difficulty in measuring the real impact was mentioned. This intervention could be best delivered by NGOs and TV companies with the expertise of designers.

Many viewed awareness raising and community building as prerequisites for the provision and improvement of community workshops. Expanding the usability of the existing workshops was agreed as the priority improvement point: In other words, making the workshop facilities and environments more friendly and inclusive for a wider demographic range of people, including women, children and elderly people, and expanding the usefulness of the workshops. This intervention could be best initiated and delivered by local authorities or NGOs with support from local communities.

3.4.2. Short-Term Medium Priority Interventions

Concerns were raised and several suggestions made regarding the four short-term medium priority interventions: Upcycling centre, materials provision service, government procurement change and community events.

Some workshop participants argued that the primary function of an upcycling centre should be collection of materials, whereas others believed that it should be a halfway house between a recycling centre and a charity shop. The major issue raised was potential rebound effect [112]: It could encourage consumers to use products for a short period of time and give them away. Therefore it might be helpful

to have gatekeepers to check the state of the materials that are entered into the centre. Fixers and upcyclers could also be present in the centre to provide a quick, affordable service. This intervention could be best delivered by local authorities partnering with NGOs.

For the materials provision service, the difficulty in processing random used or waste materials and potential legal issues (e.g., materials used by children to be limited in lead content) were identified as major issues. In order to ensure the quantity of materials, for example, new start-ups as service providers could make partnerships with local waste/recycling centres, local manufacturers and other businesses and provide a direct collection service for local households. In order to ensure the quality of materials (e.g., clean and standardised), the service providers could focus on one or two key materials. To resolve the potential legal issues, agreements could be made with partner organisations, and certified testing and guarantee could be provided. This intervention could be best delivered by companies.

Stationary goods, computers and office furnishing (Office furnishing could be based on upcycled furniture with consistent, moderate look (e.g., second-hand chairs refurbished and upholstered with same/similar colour fabrics which are either used or off-cut) so as to minimise individual uniqueness of each upcycled piece.) were suggested as suitable product categories in the case of government procurement. Some argued that extra effort might be needed to make the change more visible to the general public (e.g., press releases). Several participants expressed their doubt about feasibility due to high cost, bureaucracy and a lack of capacity in the government, and high uncertainty with Brexit (British European Union (EU) exit as the outcome of the British referendum on EU membership [113].) and increasing national debt. Regarding such feasibility issue, this intervention could also be considered as one of the first priority interventions to communicate and lobby for long-term success. This intervention could be best delivered by the government working closely with local authorities.

The use of diversified terms (such as creative reuse, repair, refurbishment, redecoration and upgrade) was recommended for widening engagement in community events. Getting multiple funders and partners as well as identifying best practice and learning from other events were also suggested. This intervention could be best initiated and delivered through the coordinated efforts by local authorities and NGOs.

3.4.3. Long-Term Priority Interventions

Many suggestions were made regarding the three long-term priority interventions: Incentives for upcycling businesses, incentives for upcycling initiatives/research and curriculum enrichment.

Increased tax on raw materials and energy consumption, reduced VAT (value added tax) on upcycled goods (and also repaired and refurbished ones) and special grants or favourable loans for upcycling businesses were suggested as incentives for upcycling businesses. Learning from other subsidies (such as for renewable energy) could give detailed information about implementation. One concern about incentives for upcycling initiatives/research was that upcycling may not be a top priority of research and action in sustainability, climate change or low carbon future. Waste management and the circular economy were suggested as a promising context for future grant and subsidy opportunities. Future research could investigate how to scale up upcycling, and the business cases to make upcycling more attractive and profitable. Both financial incentive interventions could be best delivered by the government, research councils and other funding bodies.

Many participants agreed that for curriculum enrichment upcycling should be a default process of design (i.e., how products are designed and made in the first place) and a central aspect of design education in secondary schools and universities. Design for modularity and reparability was highlighted as an important part of design education in higher education. Some argued that upcycling education should go beyond art and design (i.e., engineering education for remanufacturing) and that it should start as early as possible. Major concerns on this intervention were about the slow process and no guarantee of actual behaviour change. This intervention could be best delivered by the government and educational institutions.

4. Discussion

This section first discusses the findings from this study focusing on how they are related to the existing research, starting with approaches to and context for upcycling, then factors influencing upcycling, and key influencers. It next discusses the prioritised interventions in terms of effectiveness of similar interventions reported by previous research, and implications for implementation of the interventions. It then links the study results to transition theory and discusses scaling up upcycling in both consumption and production domains. It suggests how upcycling should be understood to achieve effective scaling up and what practical steps are next required for scaling up. The section finishes by discussing limitations of the study and suggesting recommendations for future research.

Overall, the findings on approaches to and the context for upcycling corroborated past study results from the areas of upcycling, sustainable consumer behaviour, sustainable fashion, craft and the maker movement, suggesting that UK citizens' approaches to and the context for upcycling could be broadly understood within these areas. As common upcycling materials, wood, furniture, metal, electronics, fabrics and (plastic) packaging as revealed in our study (Section 3.1.1) have been addressed in other existing studies, with wood and fabrics appearing most frequently [22,71,108,114–116]. Online shops or networks such as eBay, Gumtree, Freecycle or Freegle as frequently used source of materials (Section 3.1.1) have been described as useful sites for buying and selling (or disposing and sourcing for free) used materials, typically in households [22,108,117,118] or fashion industries [39,119,120]. Skips and charity shops (Section 3.1.1) are well-known sources of used materials amongst individual makers [22,108] and in the fashion industry [121,122]. Material selection criteria as project requirement, potential value, financial saving, quality, personal preference and ease of use (Section 3.1.1) have been reported in other studies [108,123]. The common usages of upcycled products (i.e., home DIY, gift-giving, selling) (Section 3.1.1) have been recounted in existing literature on craft and maker movement [124–127]. The predominant use of home for upcycling (Section 3.1.2) is in line with traditional and contemporary home-based craft [128,129]. Collaboration with appropriate experts (both online and offline) (Section 3.1.2) has been found at the intersection of digital and material practise of craft [130] and in maker communities [131].

Perceived benefits of upcycling revealed in this study (Section 3.1.3) were to the individual (practical and psychological/emotional) or environment. Individual benefits have been known to be a common motivator for pro-environmental behaviour [102] or sustainable lifestyles [103]. Some findings are also similar to upcycling determinants identified through reviewing the literature on craft, DIY and maker movement [21]. The social factors revealed in this study (Section 3.1.3) (e.g., social norm of being environmentally conscious, and occupational and relationship roles) confirm that norms and roles are other common motivators for pro-environmental behaviour [102,103]. Both positive and negative emotions experienced through upcycling (Section 3.1.3) support Gauntlett's [132] argument that everyday creative activities (e.g., upcycling) arouse a range of emotions, including excitement, frustration and mostly a feeling of joy. The current and childhood activities related to upcycling (Section 3.1.3) showed the continuity and repetition of similar activities over time. Habits, in the study of pro-environmental behaviours, are portrayed as either challenges to overcome or change (e.g., energy use for lighting) [81,102,133] or something to be encouraged to be developed in early years and nurtured and maintained during one's lifetime (e.g., waste separation) [134]. The latter applies to the habitual behaviours related to upcycling (Section 3.1.3). The facilitating conditions for upcycling revealed several external barriers and facilitators (Section 3.1.3). Such external, practical limits to choosing certain behaviour as well as negative perceptions on 'green' lifestyles (i.e., not for the majority) are known barriers to any pro-environmental behaviour [102]. In general, the findings on factors influencing upcycling were mostly similar to those influencing pro-environmental behaviour or sustainable lifestyle except for habits.

The results of logistic regression analyses (Section 3.2.1) demonstrated that upcycling is the type of behaviour driven by intention and is strongly influenced by attitude and subjective norm without intention–behaviour gap or an attitude–behaviour gap. (Intention–behaviour gap means the situation

where people do not take action in spite of their high intention. Attitude–behaviour gap means the situation where people do not take action regardless of their positive attitudes towards the behaviour. These gaps between intention and behaviour or between attitude and behaviour have been reported for some forms of sustainable behaviour [135–140].) The substantial influence of the subjective norm on intention and behaviour supports existing research on sustainable food consumption [141,142] or waste recycling [143,144]. Our finding that females aged over 30 appear more inclined to engage in upcycling (Section 3.2.2) may be in line with the long history of women's domestic art, craft and home improvement [145,146]. This implies that upcycling is a long-lasting common behaviour, suggesting a historical study for further research.

Other studies have reported on the effectiveness (or success or failure) of interventions similar to those that our study suggests should be prioritised (Section 3.4). For example, in the case of the two short-term high priority interventions (Section 3.4.1), mass-media campaigns have been reported to be effective in changing behaviour, most notably for health-related behaviours [147–149]. The positive impact of new media interventions (e.g., websites, social networking sites) has been shown by several studies, again for health-related behaviours [150–152]. Such existing studies have focused on short-term campaigns rather than, for example, long-term TV shows or YouTube channels. Considering the reported high effectiveness of combinations of different media with integrated strategies [151], any future media intervention should take this into account. While provision and improvement of community workshops such as Hackspace or Makerspace has not yet been reported as an effective intervention for behaviour change, it could be effective, according to the social practice theory [153,154]. (Social practice theory argues that there are three elements of practice: Material (infrastructures, objects, tools), competence (knowledge and embodied skills) and meaning (socially shared meanings, cultural conventions and expectations) [154,155]. Community workshops that provide materials, tools, space and expertise would contribute to material and competence.)

Considering the four short-term medium priority interventions (Section 3.4.2), an upcycling centre could benchmark Retuna, the world's first recycling mall in Eskilstuna, Sweden [156], or Seoul Upcycling Plaza, the world's largest upcycling cultural complex space in Seoul, South Korea [157]. Provision of stable material suppliers has also been identified as one of the particularly significant supports for scaling up small upcycling businesses in the UK [64]. The closest example of improved materials provision service could be waste banks [158] embedded in an existing waste collection system with online platforms such as Freecycle or Freegle. Government procurement (or public procurement) has been proven for its effect on stimulating innovation [159,160] and driving the market success of innovations [161]. Community events have been used and proven to promote and change healthy or sustainable behaviours such as handwashing [162] or cycling [163]. Some studies also reported that community events are more effective than mass media campaigns [164]. The potential pitfall could be the possibility that community events attract individuals already committed to upcycling or other sustainable behaviours such that they merely use the event to gain positive feedback for their lifestyle choices [165].

Regarding the three long-term priority interventions (Section 3.4.3), financial intervention has been proven to be effective for many cases, including microenterprise development [166], operation of business incubator system [167] and green supply chain management [168]. Subsidy is the most conventional form of financial intervention [169] and it has expanded the scales of some renewable energy sources (e.g., wind and solar power) and accelerated their development [170]. The risk is overcapacity (i.e., increased production without increased demand) [170]. The Swedish government's VAT reduction on repair could be a good benchmark [171]. Grants for research or initiatives are a typical way of encouraging and facilitating development of particular knowledge, practice or collaboration [172–174]. The impact of education on behaviour change has been reported as prominent in changing health-related behaviours [175–177], yet there is also a recognition that interventions relying principally on education have largely failed to achieve considerable and sustainable results for behaviour change [178]. When it comes to environmental education, Boyes and Stanisstreet [179] claim

that the effect depends on a type of behaviour and many studies have indeed reported both cases with either positive impact or no significant difference [179–182].

Regarding multiple actors to implement each intervention (Table 5), transition theory acknowledges that a transition process involves multiple actors [183–185]. Managing transitions towards a pre-defined goal such as scaling up upcycling is very challenging for a single actor to pursue due to the interdependence amongst multiple actors and autonomous developments in the socio-technical landscape [186]. A multi-actor or multi-stakeholder approach is therefore recommended for transition management [187], with multi-level governance involving interactions between multiple actors at strategic, tactical and operational levels [188,189]. For example, the contemporary transition process towards renewable and sustainable energy in the Netherlands has been occurring around the local networks of energy initiatives and other local organisations such as schools, the municipality and local economic actors (e.g., shops, restaurants, farms) in partnership with regional intermediary organisations, national networks, governmental agencies and incumbent companies, bringing in knowledge and opportunities [190].

The prioritised interventions, when implemented successfully by the coordinated efforts of multiple actors, could scale up upcycling in both consumption and production domains. In the consumption domain, buying new products (for both initial and replacement purchases) is the current regime. When the interventions are implemented, the effects may include creating a niche-cluster (Section 1.2) such as local networks of passionate hobbyists and activists for upcycling and associated activities (e.g., simple repair or reuse). Such a niche-cluster could develop into a niche-regime (e.g., regional or national networks and social movement). Another effect could be on landscape, changing the consumption culture and people's worldviews towards upcycling. The dynamic interactions between the growing niches, the changing landscape and the current regime could eventually lead to a new regime of upcycling in which ordinary consumers will often upcycle used or waste materials on a regular basis, and purchase upcycled goods for everyday needs (Figure 7).

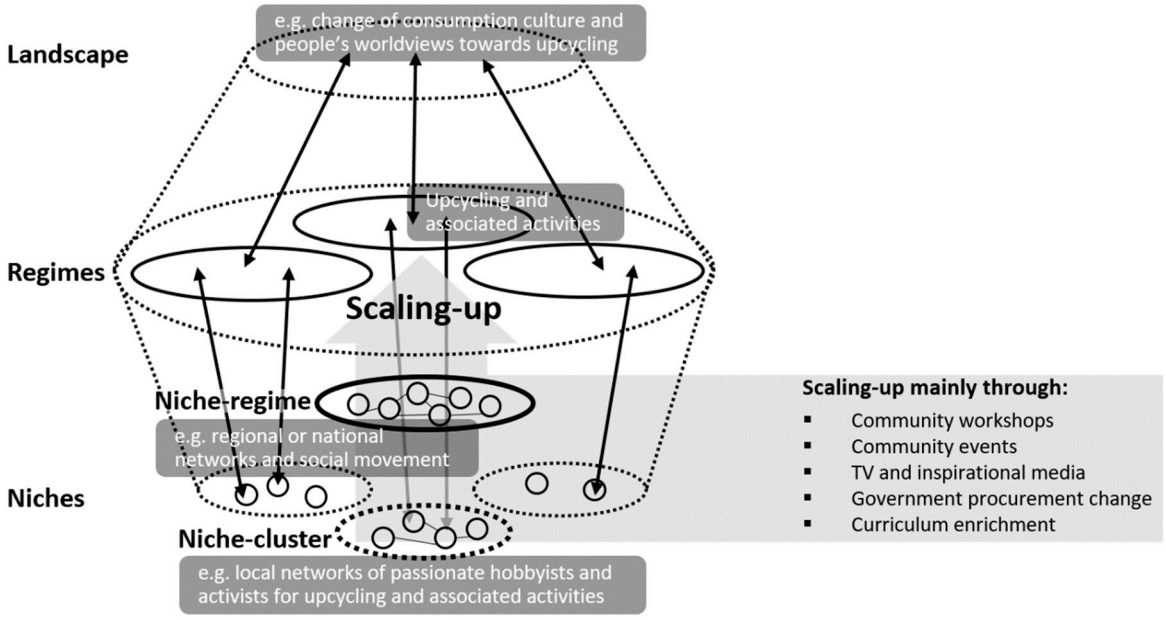

Figure 7. Scaling up of upcycling in consumption domain [15].

In the production domain, producing new products from new, virgin materials is the current regime. There are, however, already some niche-clusters such as the Ellen MacArthur Foundation [30] that bring together scientists and companies to promote a circular economy. Another niche-cluster is online networks or platforms to bring together SMEs based on upcycling craft such as Upcycled Hour [191]. When the interventions are implemented, these niche-clusters could develop into niche-regimes such

as regional, national or international networks of companies and academic institutions for industrial symbiosis [192] and knowledge transfer, or retailers of upcycled products. Scaling up interventions could also change the production culture and worldviews towards production based on used materials, components and products. The development of niches, along with the changing landscape, could enable the current regime players (i.e., mainstream manufacturers) to adjust their operations such that upcycling becomes a mode of production (business as usual) or upcycling-based SMEs to grow sufficiently to provide mainstream consumers with everyday goods (Figure 8).

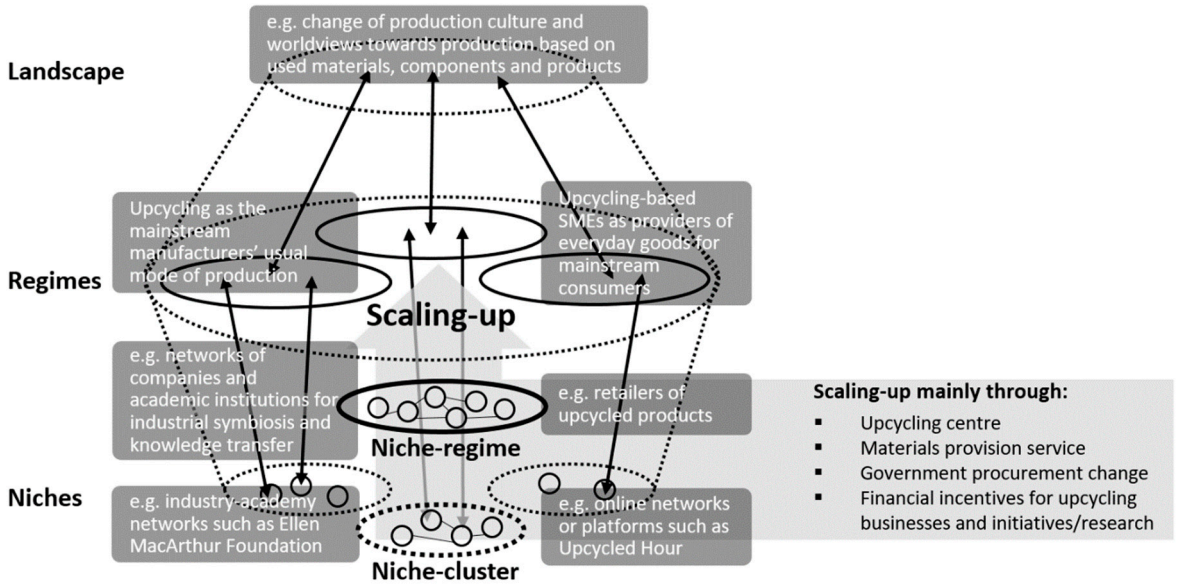

Figure 8. Scaling up of upcycling in production domain [15].

Upcycling is currently a niche behaviour (or practice) and 'a spectrum of upcycling' seemingly exists. Some authors argue that upcycling is strictly deconstructing waste products and reconstructing them into new products. Others believe that upcycling is improved (or value-added) recycling through which the quality of materials is often degraded. Some claim that upcycling is any creative process that could give a second life to any used materials, components or products. In order to achieve effective scaling up of upcycling in both consumption and production domains, the term upcycling needs to be understood and communicated as an umbrella concept that incorporates all understandings within this spectrum. Particular processes should be seen as a means to the end, upcycling. In this way, a greater number of niches can work together to form niche-clusters and develop into niche-regimes, ultimately becoming a new regime.

In order to ensure that various upcycling processes (e.g., creative forms of reuse, repair, refurbishment, upgrade, remanufacturing, recycling) escape the niche-cluster level, the skills involved in each process should not be based solely on retrograde skills in the modern world (e.g., manual repair and refurbishment). The upcycling processes should become more data driven, machine-based and specialised for higher efficiency, effectiveness and relevance to modern industrial processes.

As a next step, the prioritised interventions could be prototyped, piloted and monitored (for process and outcome) for feeding learning into large-scale implementation. The two short-term high priority interventions (Section 3.4.1), therefore, should be the first to be prototyped and piloted by any actors aiming to scale up upcycling. The four medium priority interventions for the short term (Section 3.4.2) might also be considered for prototyping and piloting simultaneously with (or after) the two high priority interventions. The three long-term priority interventions (Section 3.4.3) could be widely communicated with lobbying activities to influence key decision makers in the government and educational institutions.

When it comes to limitations of this study, the results from the interview and survey studies may not be generalisable to the overall UK population due to the purposive sampling used and limited sample size. The generalisability is restricted by the geographic and demographic focus of the study, and therefore findings and practical implications are applicable only to the UK context. Another limitation in interviews was that some questions based on the behaviour model used technical language about each factor instead of more understandable wording (e.g., asking if any "self-concepts" are involved in participants' motivation instead of, for example, "What sort of people might participate in upcycling?"). This means that potentially more interesting and valid answers may not have been attained. Moreover, some participants may not have been aware of the factors influencing their behaviour. A limitation in the survey is that factors used to explain upcycling behaviour (as frequency of past behaviour) may not predict future behaviour. Further, the semi-Delphi results are based on the opinions of a certain group of experts, but other experts may reach different conclusions and recommendations.

Considering the limited, focused scope of this research, further studies on upcycling could be conducted concerning: (a) Upcycling as practice rather than behaviour based on different theoretical frameworks such as social practice theory [154]; (b) upcycling as behaviour but focusing on different behaviour domains other than sustainable behaviour such as community participation or mental health; (c) upcycling in countries other than the UK; (d) development of interventions for scaling up upcycling at the EU level or international level; (e) exploration of a wider cultural context behind upcycling behaviour/practice; (f) commercial perspectives of upcycling—the profitability of different product categories and scalability of the businesses; and (g) measuring the net environmental impacts of upcycling. The most interesting future research would be action research on the process of prototyping and piloting the recommended interventions for scaling up upcycling. It would aim not only to measure its impact on scaling up but also to report the lessons learned during the process.

5. Conclusions

Recognising the knowledge gap in household upcycling as individual behaviour and the significance of upcycling to contribute to reductions in GHG emissions, this research aimed to develop interventions for scaling up UK upcycling, focusing on households. In order to meet this aim, three objectives were set: (a) Gain insights into UK upcycling; (b) discover key factors influencing UK upcycling; and (c) develop interventions for scaling up upcycling. The first objective was accomplished through thematic analysis of interviews with UK citizens on current upcycling behaviour and factors influencing upcycling. The second objective was achieved through statistical analysis of the online survey responses on the factors influencing upcycling. Key determinants of upcycling were identified and several statistically significant group differences based on demographics were found. The third objective was fulfilled by intervention development and the use of semi-Delphi. Several interventions were generated on the basis of the synthesis of the interview and survey studies, followed by mapping and additional idea generation. Through the semi-Delphi study exploring and evaluating the initial interventions, important and feasible interventions for short and long terms were suggested. The paper further provided the discussions on how the study results are related to past research and how they can be used for future action for scaling up upcycling in the UK.

The paper presents the first study to develop interventions for scaling up UK upcycling. It extends our understanding of how upcycling has been undertaken in UK households, why individuals engage in upcycling, and how to develop interventions. The paper hence contributes to both theoretical and practical development on upcycling. The process as a whole (qualitative and quantitative investigation into the subject, synthesis of results, intervention development and evaluation of interventions) could be applied to other contexts and behaviour domains for behaviour investigation and intervention. It is our hope that our findings will inform academic researchers for further studies on upcycling and related areas, and motivate and enable relevant actors to contribute to scaling up upcycling in the UK and in other parts of the world.

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Appendix A. Interview Questions to Gain Insights into Upcycling

Category	Sub Category	Questions
Approaches to upcycling	Upcycling materials	What kinds of materials do you use for upcycling?
	Ways of acquiring materials	Where or how do you get the materials?
	Material selection criteria	How or why do you choose particular materials?
	End product usage	What do you do with the end products after upcycling?
Context for upcycling	When	When do you usually upcycle?
	How often	How often do you upcycle?
	Where	Where do you usually upcycle?
	With whom	Do you upcycle by yourself or with others? If with others, who are they? What is the occasion?
Factors influencing upcycling	Perceived benefits	What benefits do you expect and see from upcycling?
	Norms	Norms are social beliefs that certain behaviours are appropriate, correct or desirable. Are they any social norms involved in your motivation?
	Roles	Roles are particular positions in a group, for example, as son or daughter, partner, father or mother, friend, employee, etc. Are there any of your roles involved in your motivation?
	Self-concept	Self-concept is your idea of who you are. For example, I am the kind of person who does this. Are there any of your self-concepts involved in your motivation?
	Any other motivations	Are there any other motivations for upcycling besides what you have already mentioned?
	Emotions	What positive or negative and strong or weak emotions do you feel when upcycling? What emotions do you feel when you complete upcycling?
	Habits	What other activities do you habitually engage in, relating to upcycling? Do you have any childhood activities related to upcycling?
	Facilitating conditions	Before your first upcycling, what were the barriers? Why were you not upcycling? Have you experienced any problems or difficulties with upcycling? What conditions do you think have facilitated your upcycling so far?

Appendix B. Fifteen Interventions Used for Testing/Evaluation

1. Community workshops: Improve services and facilities of, and access to community workshops with materials, tools, training and space
2. Novice toolkits: Design and provide toolkits for notice upcyclers
3. Upcycling centre: Operate a reuse/upcycle centre with a product collection service aligned with existing waste collection system
4. Materials provision service: Design and provide a service model for improved provision of used materials
5. Curriculum enrichment: Enrich the curriculum in art and design at schools, colleges and universities to incorporate advanced upcycling knowledge and skills
6. Community events: Organize community-based upcycling events and training sessions
7. Competitions: Organize upcycling competitions in schools, universities, communities and industry
8. Business consulting: Provide advice and consultancy on upcycling businesses (feasibility and safety test, market identification)
9. Communication: Design and provide effective communication materials for the general public and industry
10. Campaign: Design and provide a wow experience as an upcycling promotion campaign
11. TV and inspirational media: Produce TV shows and other inspirational media to share the best practices
12. Incentives for upcycling businesses: Provide tax benefits and subsidies for upcycling-related businesses
13. Incentives for upcycling initiatives/research: Provide grants and subsidies for upcycling-related initiatives and research
14. Commissioned projects: Demonstrate high quality and value of upcycling through commissioning high profile upcycling projects by famous artists and designers
15. Government procurement change: Demonstrate upcycled goods as a new social norm or standard by changing government procurement policy to favour upcycled goods

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